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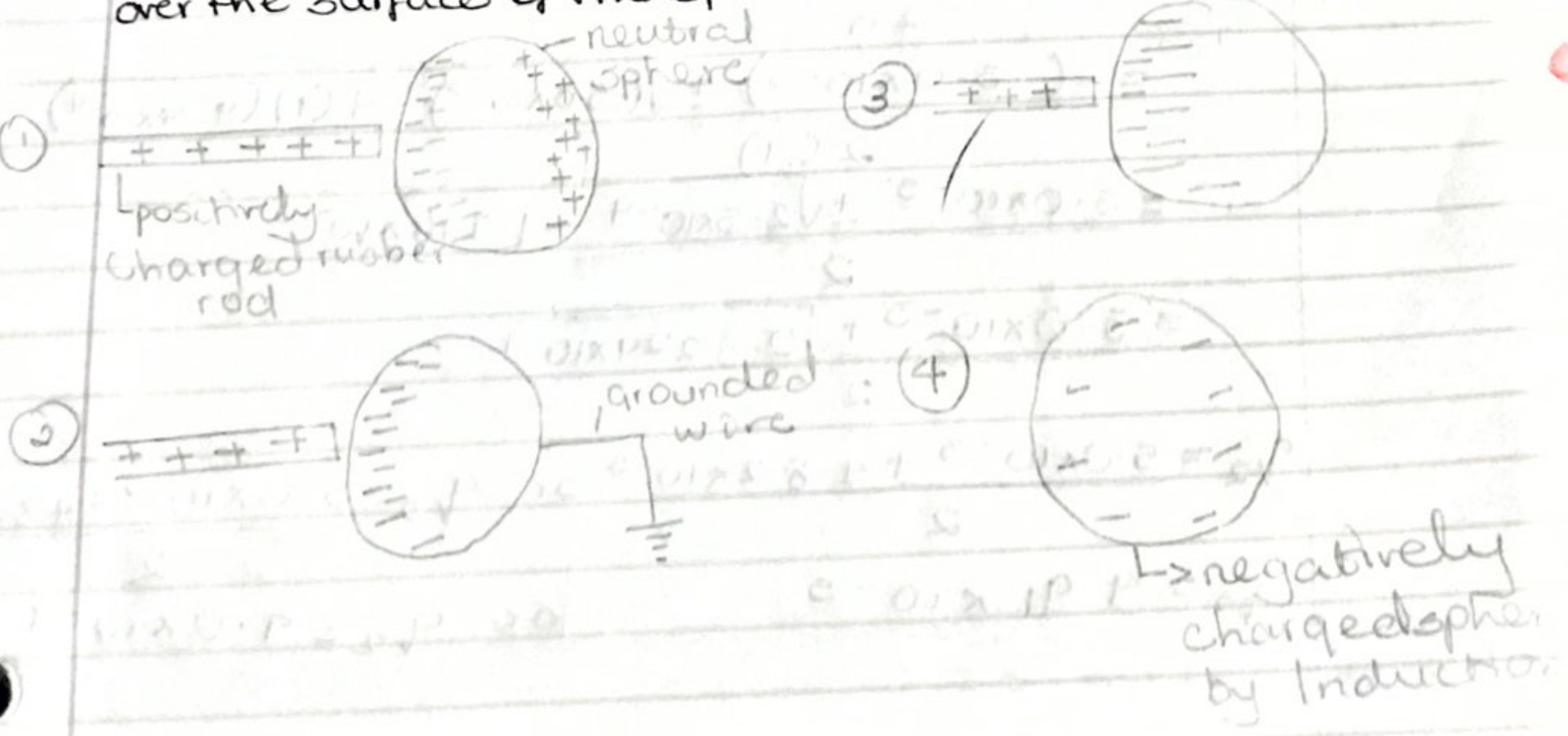
PHY102 ASSIGNMENT (COVID-19 HOLIDAY ASSIGNMENT)
MBBS 19/MHS01/192

1a To produce a negatively charged sphere by the method of induction, a positively charged ~~metal~~ rubber rod is brought near an uncharged (neutral) conducting sphere which is insulated. There is a repulsive force between the electrons in the rod and those in the sphere thus causing a redistribution of charges in the sphere so that some electrons move to the side of the sphere which is farthest away from the rod. The side of the sphere near the rod has an excess of negatively charge while the side farthest from the rod contains positive charges. A grounded conducting wire is then connected to the sphere and some electrons (positive charges) then leave the sphere and travel to the earth. The grounded wire is then removed leaving the sphere with an excess of induced negative charges. Finally, the rubber rod is removed from the sphere's area. The Induced negative charges remain on the ungrounded sphere and becomes uniformly distibuted over the surface of the sphere.



DIAGRAMS EXPLAINING THE PROCESS OF PRODUCING NEGATIVELY CHARGED SPHERES THOUGH IDUCTION.

1b Given that $F = \cancel{0.1N}\ 1.0$, $r = 2m$, $q_1 + q_2 = 5.0\times10^{-5}C$, $K = 9\times10^{9}Nm^2/C^2$

From Coulomb's law; $F = \frac{Kq_1q_2}{r^2}$

$$F = \frac{Kq_1q_2}{r^2}$$

$$2^2 \times \cancel{0.1}\ 1.0 = \frac{9\times10^{9}\, q_1q_2}{2^2} \times 2^2$$

$$\cancel{0.1} = \cancel{2.25\times10^{9}}\ q_1q_2$$

$$\frac{0.4}{9\times10^{9}} = \frac{\cancel{9\times10^{9}}}{\cancel{9\times10^{9}}}\, q_1q_2$$

$$q_1q_2 = 4.44\times10^{-11} \quad —(1)$$

Recall $q_1 + q_2 = 5.0\times10^{-5}$

$$q_1 = 5.0\times10^{-5} - q_2 \quad — eq(11)$$

Sub eq(11) in eq(1)

$$(5.0\times10^{-5} - q_2)\, q_2 = 4.44\times10^{-11}$$

$$5.0\times10^{-5} q_2 - q_2^2 = 4.44\times10^{-11}$$

$$\underset{a}{1q_2^2} - \underset{b}{5.0\times10^{-5}} q_2 + \underset{c}{4.44\times10^{-11}} = 0$$

Using quadratic formula

$$q_2 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-(-5.0\times10^{-5}) \pm \sqrt{(-5.0\times10^{-5})^2 - 4(1)(4.4\times10^{-11})}}{2(1)}$$

$$= \frac{5.0\times10^{-5} \pm \sqrt{2.5\times10^{-9} - 1.776\times10^{-10}}}{2}$$

$$= \frac{5.0\times10^{-5} \pm \sqrt{2.3224\times10^{-9}}}{2}$$

$$q_2 = \frac{5.0\times10^{-5} + 4.82\times10^{-5}}{2} \quad \text{or} \quad q_2 = \frac{5.0\times10^{-5} - 4.82\times10^{-5}}{2}$$

$$q_2 = 4.91\times10^{-5} \quad \text{or} \quad q_2 = 9.0\times10^{-7}$$

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Using $q_2 = 4.91\times10^{-5}$

$q_1 = 5.0\times10^{-5} - 4.91\times10^{-5}$

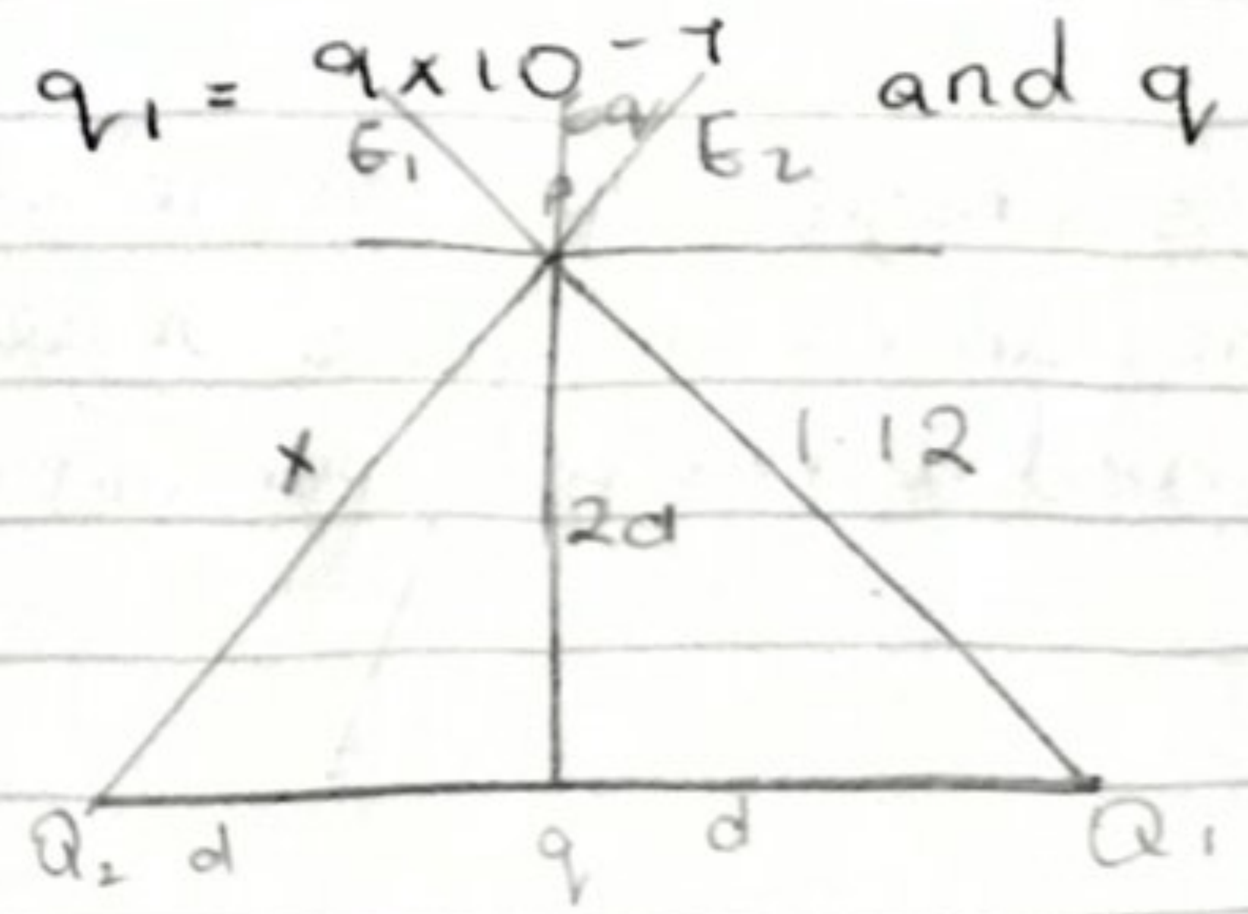
$q_1 = 9\times10^{-7}$

To prove $q_1 + q_2 = 5\times10^{-5}$

$9\times10^{-7} + 4.91\times10^{-5} = 5\times10^{-5}$

$\therefore q_1 = 9\times10^{-7}$ and $q_2 = 4.91\times10^{-5}$

1c



$d = 0.5m$, $Q_2 = Q = 8\times10^{-6}$

$E_2 = E_1$

Eq at $P = 0$

$x^2 = 0.5^2 + (2\times0.5)^2$

$x^2 = 0.25 + 1.0$

$x^2 = 1.25$

$x = \sqrt{1.25}$

$= 1.12$

$\tan\theta = \frac{opp}{adj}$

$\theta = \tan^{-1}\left(\frac{1}{0.5}\right)$

$\theta = 63.43^\circ$

~~Eq~~ Enet at $P = 0$

$E_1 = \frac{Kq_2}{r^2}$

$= \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2}$

$E_1 = 57397.95918$

$E_2 = 57397.95918$

Vector	Angle	x - comp	y - comp
$E_1 = 57397.9598$	63.43	25700.45785	51322.62839
$E_2 = 57397.95918$	63.43	-25700.45785	51322.62839
		$Ex = 0$	$Ey = 102643.256$

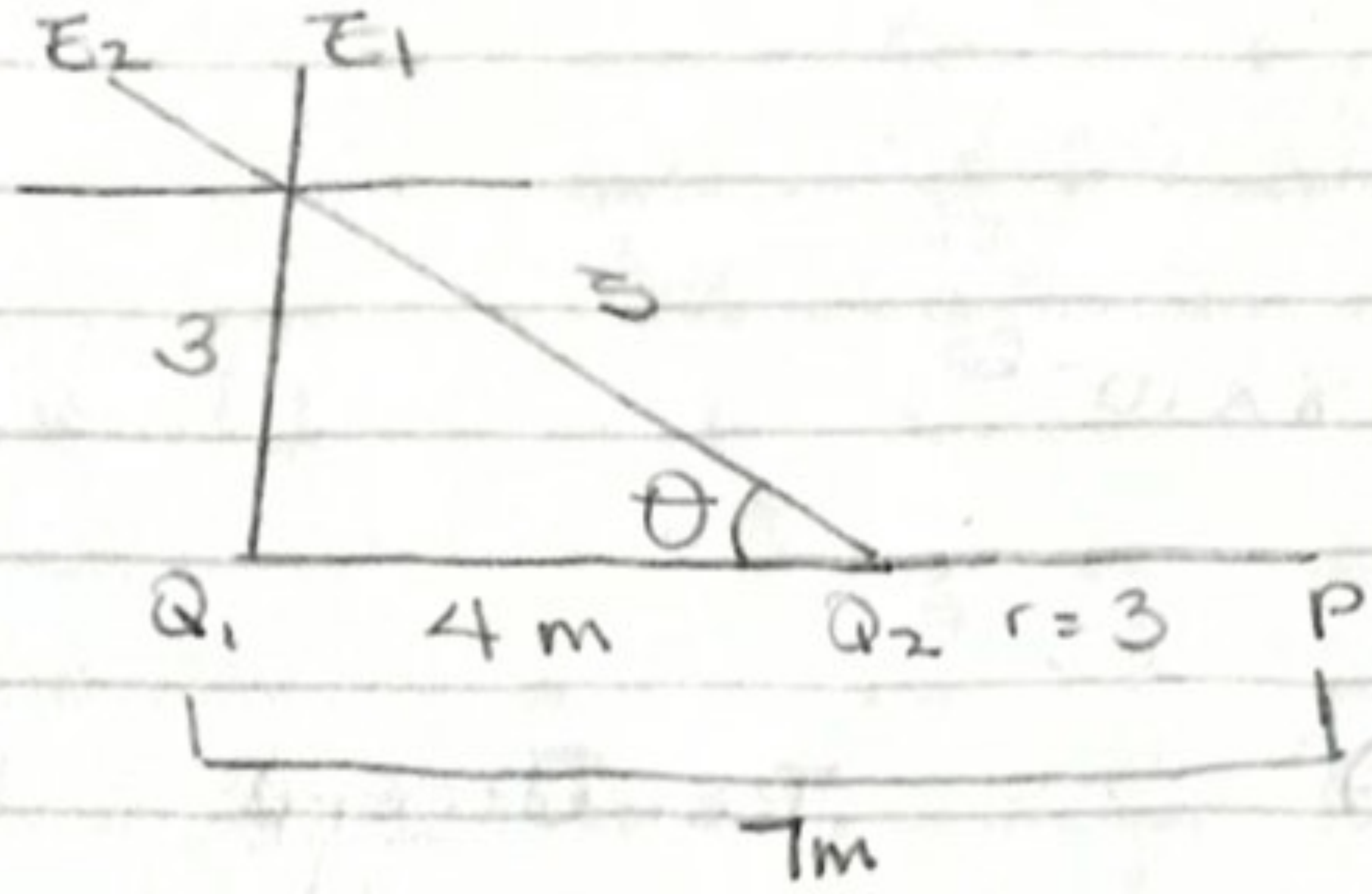
$Eq = \sqrt{(0)^2 + (102645.2568)^2}$

$Eq = 0 + 102645.2568$

$q = \frac{Eq}{9\times10^9} = \frac{102645.2568}{9\times10^9}$

$\therefore q = 1.14\times10^{-5} C$

2a An electric field is a region of space in which an electric charge will exprience an electric force while Electric field intensity can be defined as the force per unit charge.

b. 

$\tan\theta = \frac{opp}{adj}$

$\theta = \tan^{-1}\left(\frac{3}{4}\right)$

$\theta = 36.9^\circ$

$E_{net} = E_1 + E_2$

$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469 N/C$

$E_2 = \frac{Kq_2}{r^2} = 9\times10^9 \times 12\times10^{-9} = 12 N/C$

$E_{net} = 12 + 1.469$

1) $E_{net} = 13.469$ or $13.5 N/C$

(5)

11 $E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$

$E_2 = \frac{KQ_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$

Vector	Angle	x-comp	y-comp
$E_1 = 8N/C$	$90°$	0	8
$E_2 = 4.32N/C$	$36.9°$	-3.45	2.59

$E_x = -3.45$ $E_y = 10.59$

$E_{net} = \sqrt{(-3.45)^2 + (10.59)^2}$

$E_{net} = 11.14N/C$ //

5a Biot-Savart law states that the magnetic intensity at any point due to a steady current in an infinitely long straight wire is directly proportional to the current and inversely proportional to the distance from point to wire.

b Applying the biot-savart law, we find the magnitude of the $d\vec{B}$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl \sin \theta}{r^2}$$

$$\sin(\pi - \theta) = \sin\theta$$

$$\therefore B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl \sin(\pi-\theta)}{r^2}$$

Using pythagoras theorem in from the diagram $r^2 = x^2 + y^2$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl \sin(\pi-\theta)}{x^2+y^2} \quad \text{---} (1)$$

But $\sin(\pi - \theta) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}}$ — (2)

Substitute eq(2) in eq(1)

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \frac{x}{(x^2+y^2)(x^2+y^2)^{1/2}}$$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \cdot \frac{x}{(x^2+y^2)^{3/2}}$$

Recall $dl = dy$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{x}{(x^2+y^2)^{3/2}} dy$$

$$B = \frac{\mu_0 I x}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}} dy \quad — (3)$$

Using special integrals

$$\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} \frac{y}{(x^2+y^2)^{1/2}}$$

Eq(3) ∴ becomes

$$B = \frac{\mu_0 I x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$$

$$B = \frac{\mu_0 I x}{4\pi}\left(\frac{2a}{x^2(x^2+a^2)^{1/2}}\right)$$

$$B = \frac{\mu_0 I}{4\pi x}\left(\frac{2a}{(x^2+a^2)^{1/2}}\right)$$

When the length of 2a of the conductor is very great compared to its distance x from point P, we consider it infinitely long. That is when a is much larger than x

$(x^2+a^2)^{1/2} \cong a$; as $a \to \infty$

$$\therefore B = \frac{\mu_0 I}{2\pi x}$$

In a physical situation, we have axial symmetry about the y-axis. Thus, at all points in a circle of radius r, around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \quad \ldots (*)$$

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Eq (*) defines the magnitude of the magnetical field of flux density B near a long, straight current carrying conductor

4a Magnetic flux is the measure of the strength of a magnetic field in a given area.

b rest Mass of electron = 9.11×10^{-31} kg $q = -1.6 \times 10^{-19}$
radius = 1.4×10^{-7} m
Magnetic field = 3.5×10^{-1} weber/m²
Cyclotron frequency = Angular speed = ω

$r = \frac{mV}{qB}$ $\omega = \frac{V}{r} = \frac{qB}{m}$

$\omega = V \div r$

$\omega = V \div \frac{mV}{qB}$

$\omega = \cancel{V} \times \frac{qB}{m\cancel{V}}$

$\omega = \frac{qB}{m}$

$= \frac{-1.60 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

$\omega = -6.15 \times 10^{10}$ rad/s

c The answer is negative because we are dealing with an electron which is moving at a cyclotron frequency of 6.15×10^{10} rad/s